# Efficient Energy Consumption & Economic Growth

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Energy plays a pivotal role in the development of a region. Increasing dependency on fossil fuels has caused serious concerns at the local (energy dependency, pollution, etc.) and global (global warming, GHG emission, etc.) levels. Harvesting of energy depends on the availability of resources apart from the economic viability and technical feasibility of meeting the demand. The energy requirement of India is mainly supplied by coal and lignite, followed by crude oil and petroleum products and electricity.

However, energy consumption in rural India is largely dependent on non-conventional energy sources due to the availability, possibility of rapid extraction, and appropriate technologies. Globalization and consequent opening up of Indian markets has led to urbanization with the enhanced energy demand in the industrial and infrastructure sectors. There is a need to navigate the energy transition for sustainable growth in socio-economic aspects of the country. Though the energy consumption per GDP (Gross Domestic Product) is higher, production of valuable goods is quite low in the country which shows that there is a need to improve the end-use efficiency. Coupled with this inefficiency, the perishing stock of global fossil fuel reserves and the growing concerns of global warming and consequent changes in the climate has necessitated the improvements in end use energy efficiency along with the exploration of cost effective, environment friendly, and sustainable energy alternatives.

Renewable sources of energy such as solar and wind are emerging as viable alternatives to meet the growing energy demand of the burgeoning population. Strengthening of transmission and distribution network with the integration of local generating units (RE-based standalone units) would help in meeting the demand. Distributed generation (DG) with micro grids are required to minimize transmission and distribution (T and D) losses, and optimal harvesting of abundant local resources (such as solar, biofuel, etc.). The focus of the current communication are i) understanding the energy scenario in India; ii) sector- and source-wise energy demand with the scope for energy conservation; and iii) prospects of renewable energy with smart grids to meet the distributed energy demand while optimizing harvest of local energy sources. Per capita energy consumption varies across countries (based on the analysis of 2004-05 and 2014-15). It is higher in developed nations (USA-7.3 TOE, Canada-7.6 TOE, Japan 3.7 TOE) compared to the developing (India-0.6 TOE, China-1.8 TOE, Brazil-1.4 TOE) and less developed nations (<0.4 TOE). Figure 1 compares the energy consumption per capita versus GDP (Gross Domestic Product) per capita among the countries (Top 25 GDP countries). Norway (99,933 million USD) tops in GDP per capita followed by Switzerland (79,024 million USD), Australia (65,430 million USD) and Sweden (55,341 million USD) which shows the effective utilization of energy. The per capita GDP value of India is 1555.50 million USD, which is lowest among these countries. But, Energy consumption per GDP (Energy intensity) of India is higher, hinting the inefficient use of energy. Figure 2 compares the energy intensity (the ratio of energy consumption per GDP) versus GDP per capita of various countries. Energy intensity of India is about 0.42 kgoe/million USD which is more than 12 times that of Switzerland (0.033 kgoe/million USD), more than 4 times that of Germany (0.092 kgoe/million USD), more than 3 times that of USA (0.137 kgoe/million USD) and about 1.3 times that of China (0.325 kgoe/million USD). The prosperity of a nation depends on the efficient use of energy or the energy intensity than the per capita energy consumption.

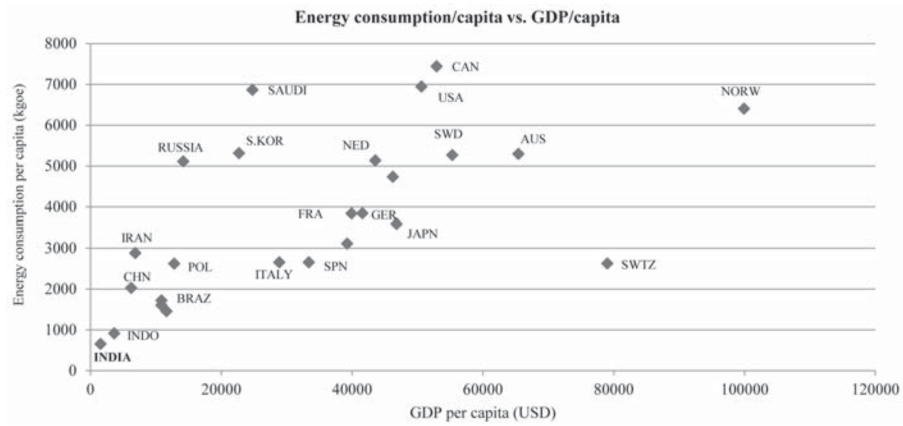

Figure 1: Country-wise energy consumption per capita versus GDP per capita

Most of the Asian countries have high energy intensity (energy/GDP) and lower per capita consumption, which illustrates the inefficient use of energy. This highlights the need of improved end use efficiency to enhance the GDP with the present level of energy consumption.

Global studies also emphasize the efficient use of the energy have also demonstrated the relationship between efficient energy consumption and economic

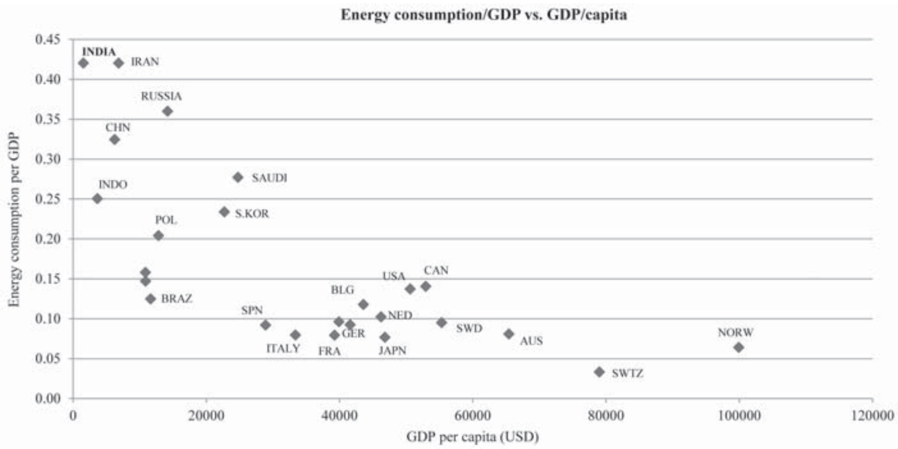


Figure 2: Country-wise energy consumption per GDP versus GDP per capita

growth. Emission of greenhouse gases (GHG) is proportional to energy utilization and is found higher in developing countries due to the inefficient use of energy.

## End-use efficiency improvement

More than 70 per cent of the population resides in rural regions and 85 per cent of the energy requirement is met by traditional fuel through energy inefficient devices. Industrial energy consumption is also inefficient in most of the cases due to the aged equipment, lack of lubrication, torn out parts, and non-scientific combustion. The overuse of energy resources in the commercial domain and unmetered energy supply for irrigation pumps have aggravated the energy crisis.

The primary need of energy resources in rural India is for cooking, water/space heating, and lighting. Most of the energy for cooking and heating is supplied by bioenergy (fuel wood, dung cake, etc.) which is locally available. However, the conventional cook stoves used for combustion of biomass have lower thermal efficiency (<10 per cent). Compared to these, improved cook stoves (ICS) have higher efficiency (20–30 per cent) and there is a scope to reduce 27 to 42 per cent of the fuel wood requirement. A typical rural household consumes about 5l of kerosene every month. Average electricity consumption in rural household ranges between 50–60 kWh/month which is mainly used for lighting, entertainment, water pumping, and air cooling. About 30–40 per cent of energy conservation is possible in the domestic sector using CFL/LED lamps for lighting, energy efficient heaters, and coolers.

The domestic energy requirement of an urban household is supplied by electricity, LPG (Liquefied Petroleum Gas), fuel wood, etc. Even though an urban household consumes about 11 kg of LPG per month, 22 per cent of the urban households depend on firewood and kerosene as primary energy need. Electricity is the main source of lighting, cooling, and water heating in urban area where the consumption ranges from 100–125 kWh per month. Use of ICs, CFL/LED lamps, and energy efficient heaters and coolers can conserve a significant amount of energy. Solar water heater and rooftop solar PV installation can substitute electricity and biomass consumption for lighting and water heating, respectively.

Energy conservation in irrigation pump sets is possible by avoiding over capacity installation, maintenance and lubrication, selecting proper foot valves and pipelines, drip irrigation, and sprinkler installation, etc. Energy supply for agricultural purposes is to be metered and tariff has to be applied on the basis of installed capacity. This would help in the optimal irrigation of agriculture

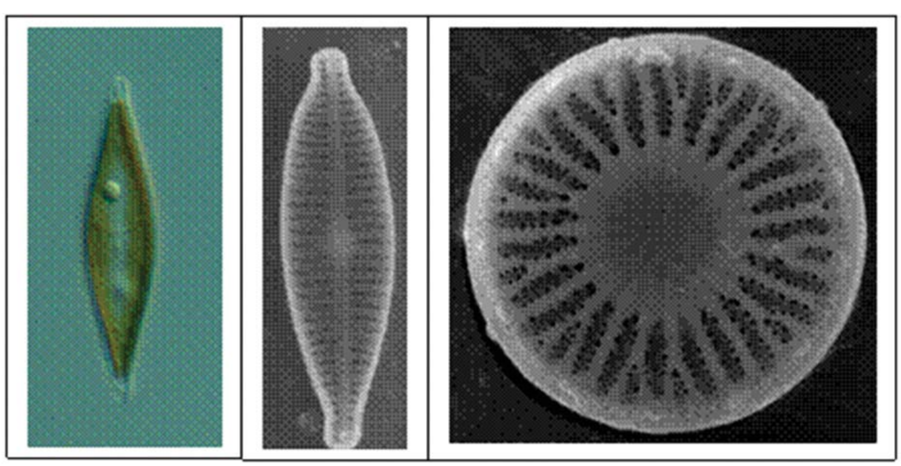

Figure 3: Pennate and centric diatoms (*Navicula sp.*, with an oil droplet)

fields. Wind pumps and solar PV pumps can be installed for small area irrigation (5–10 hp) which would replace the diesel or kerosene fueled pumps.

Industries are the highest energy consumers in India which use all forms of energy resources. Many of the Indian industries use coal, oil, and electricity. About 30–40 per cent of energy conservation is possible with upgradation of equipment and technology. However, there is a need to reform policies and tariffs for industrial energy consumption to promote captive generation through renewable energy sources. Energy consumption in the commercial sector has increased considerably during the last decade. Energy conservation in the commercial sector through interventions in lighting technologies (LED/CFL), green buildings, and energy efficient equipment would reduce the energy consumption and decrease the energy intensity.

## Innovations in Energy Sector

Development of economically viable and technically feasible new energy harvesting technologies is expected to change the present energy mix. Technology innovation in non-fossil energy resources - solar thermal and PV, bioenergy, off-shore wind, hydrogen, artificial photosynthesis, etc. would meet the future energy demand. The current focus is on bioenergy, bio-oil, and biological hydrogen production. Technologies like bio-oil and ethanol production from algae would significantly replace the fossil oil for transportation and electricity generation. Many of

these technologies are in the lab scale at the moment and thus, have shown great potential in cutting down the cost and also tapping a wide range of renewable energy sources.

In the face of increasing $CO_2$ emissions from conventional energy (gasoline) and the anticipated scarcity of crude oil, a worldwide effort is underway for cost effective renewable alternative energy sources. Efforts are in progress at Energy & Wetlands Research Group, CES, at the Indian Institute of Science, Banaglore, towards developing the gasoline secreting diatom solar panels to produce gasoline from diatoms sustainably. Diatoms being the major group of planktonic algae (Figure 3) can be used sustainably for production of bio-fuel, by the usage of diatom-based solar panels. Studies have shown that diatoms could make 10 to 200 times as much oil per hectare as oil seeds and the techniques involved towards developing oil secreting diatoms to minimize the cost of oil extraction. It was found that some diatoms secrete more lipid content when subjected to unfavorable environment or culture conditions, such as nutrient starvation or extreme temperatures. Unlike crops, diatoms multiply rapidly. Some diatoms can double their biomass within an hour to a day's time. Since each diatom creates and uses its own gas tank, it is estimated that diatoms are responsible for up to 25 per cent of global carbon dioxide fixation. This means that while diatoms can be cultivated for oil extraction, they can automatically reabsorb carbon dioxide in the process. Diatoms may have a major role to play in the coming years with regard to the mass production of oil. This entails appropriate cultivation, harvesting and extraction of oil, using advanced technologies that mimic the natural process while cutting down the time period involved in oil formation. EI


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